its maximum address (N), the bit outputs become time varying square wave signals of period (N/f), where f is the clocking frequency of the address. As shown in FIG. **10**, these bit images of the waveforms can be set to maintain a relative phase shift with respect to each other. Although only eight bit waveforms are shown, the number of possible waveforms is not limited, and such a scheme can drive any desired number of transducers.

The circuitry for generating square wave signals of different relative phases for each transducer is also simplified when only a fixed number of beam directions is required. In this case, the waveforms specifying a particular beam direction can be stored as "pages" in the memory element. A practical embodiment of a circuit for accomplishing this is shown in FIG. **11**, in which the digital waveform data for driving eight transducers are stored in eight pages of 128 memory locations each. The memory space of each page, 128 address locations, is sufficient to specify a phase to a precision of about three degrees. A dual-port read/write memory **42** circuit is utilized to store the waveform data, which allows the waveform data to be written into the memory **42** and updated if necessary by a processor (not shown) coupled to the memory **42**. Counter circuits **44** are provided so that a 10 MHZ local oscillator **46** cycles through 122 memory locations at a rate, 40.98 kHz, sufficiently close to the resonant frequency, 41 kHz, of the selected transducer elements. The waveforms are encoded in these 122 memory locations, and drive circuits **48** are used to convert the digital waveform data pulses into the high voltage needed to drive the particular transducers.

FIG. **12** graphically illustrates the beam pointing ability for the 41 kHz resonator array illustrated in FIG. **10**. In this example, the relative phases of the eight array sources were adjusted to give maximum signal strength directly in front of the array, at 0 degrees; and then at a direction 18 degrees away from the plane of the resonator columns. The ability of the array to direct the acoustic signals in these directions is demonstrated in this figure.

FIG. **13** is an example of the performance of a direction and ranging system built from a 41 kHz linear acoustic array illustrated in FIG. **10**, the electronic driver circuitry illustrated in FIG. **11**, and an ultrasonic receiver. The receiver was in proximity to the acoustic array, and it received ultrasonic energy reflected from nearby room objects. The range to an object was determined by the transit time of a 1 msec acoustic wave pulse from the linear array. The beam from the linear array was steered into eight vertical directions separated by about five degrees. The figure represents an intensity map for a chair at far range.

The invention provides acoustic data indicative of range, angular direction and angular extent of an object within a scanned field. Based on this data, the system processor **18** can determine range based on the time required to receive the acoustic signal, angular direction based on the angle of the steered beam when the acoustic signal is detected, and angular extent based on the arc of the steered beam during which the acoustic signal is detected. This information can be utilized in an occupant detection system to control deployment of an air bag and prevent unwanted injuries. For example, the rate of inflation of the air bag may be made dependent on the range of the occupant. Further, the angular extent of the occupant can be utilized to control the force of deployment, so that occupants of smaller stature or children are not subjected to the maximum deployment force of the air bag.

FIG. **14** illustrates an occupant detection system in accordance with the invention that include a sensor module **50** mounted to a dashboard **52** of a vehicle **54**. The sensor module **50** includes the array of acoustic output transducers **12** and input transducer **20** discussed above, and is positioned so that a steered acoustic beam emitted from the array of acoustic output transducers **12** is directed to a passenger seat **56** located within a passenger compartment **58** of the vehicle **54**. The sensor module **50** is coupled to a controller **60** that contains the various processing circuitry previously described that is required to drive the array of acoustic output transducers **12** and to analyze the signals received from the input transducer **20**. The controller **60** controls the activation of the air bag **62** in response to the signals received from the input transducer **20** of the sensor module **50**, such that the air bag **62** is deployed within a prescribed envelope **64** within the compartment **58**.

The invention has been described with reference to certain preferred embodiments thereof. It will be understood, however, that modification and variations are possible within the scope of the appended claims. For example, the sensor module may be located at positions within the passenger compartment other than the dashboard, and may also be employed to detect objects in compartments other than the passenger compartment, as in the case of a child trapped in the trunk of a vehicle. Also, the number of transducers utilized in the array may vary along with their operating frequency. Still further, multiple modules may be employed so that steered beams are generated in more than one plane.

What is claimed is:

1. A detection apparatus for detecting an object within a vehicle comprising:

a compartment in the vehicle;

an acoustic wave transmitter that generates a steered acoustic signal in the compartment of the vehicle;

a receiver that receives a reflected acoustic signal generated by the reflection of the steered acoustic signal off objects located within the vehicle compartment; and

a controller coupled to the receiver, wherein the controller, using the reflected steered acoustic signal, determines at least one of range, angular extent and angular direction of the object.

2. A detection apparatus as claimed in claim **1**, wherein the controller converts waveform data stored in a memory to electrical drive signals that are supplied to the transmitter.

3. A detection apparatus as claimed in claim **1**, wherein the controller controls deployment of an air bag based on at least one of range, angular extent and angular direction of a detected object.

4. A method for detecting an object, the method comprising the steps of:

providing three or more ultrasonic acoustic wave transmitters, each producing an ultrasonic acoustical wave that has a wavelength and a phase;

positioning the three or more ultrasonic acoustic wave transmitters in a linear array spaced within one wavelength of an adjacent transmitter;

adjusting the relative phase of selected ultrasonic acoustic wave transmitters to produce a steered acoustic beam;

receiving a reflected acoustic signal generated by the reflection of the steered acoustic beam off the object; and

determining at least one of range, angular extent and angular direction of the object from the reflected steered acoustic beam.

5. A method according to claim **4** wherein the relative phase of selected acoustic wave transmitters is varied to produce a sweeping steered acoustic beam.